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Gem Stones

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This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals and Minerals; Volume II, Area Reports: Domestic; Volume III, Area Reports: International.* The separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C. 20402.

Gem Stones

By Gordon T. Austin[1]

The value of natural gem materials, gem mineral specimens, and natural and cultured freshwater pearls produced in the United States was estimated to be $21.4 million, an increase of 130% over that of 1986. The significant increase reflects both a true increase in production and an increase in the number of producers surveyed. Small mine owners and professional and amateur collectors accounted for most of the production. Small mines produced tourmaline, jade, opal, sapphire, turquoise, agate, lapis lazuli, garnet, beryl, and quartz.

The combined value of synthetic and simulant gem stones was reported to be $15.3 million, an increase of 49% over that of 1986. The increase reflects an actual increase in production. Synthetic gem stones are manmade and have the same optical, physical, and chemical properties and the same appearance as the natural gem stone. Synthetic gem materials produced in the United States include ruby, sapphire, garnet, spinel, alexandrite, quartz, emerald, turquoise, lapis lazuli, coral, and diamond. Simulants are manmade gem materials that have an appearance similar to that of a natural gem material but have different optical, physical, and chemical properties. The gem simulants produced in the United States include turquoise, coral, lapis lazuli, malachite, and cubic zirconia. Cubic zirconia is the major simulant and is produced in colored and colorless varieties.

The gem stone materials are sold to wholesale and retail outlets, in gem and mineral shops, at gem and mineral shows, to cutting factories, and to jewelry manufacturers.

Domestic Data Coverage.—Domestic production statistics for gem materials were developed by the Bureau of Mines from the "Gems and Gem Stones Survey," a voluntary survey of U.S. operations, and from Bureau estimates of unreported production. Of the 267 operations to which a survey request was sent, 91% responded, accounting for 95% of the total production, 92% of the natural production, and 100% of the synthetic and simulant production.

The 267 operations surveyed in 1987 were an increase of about 154% compared with the number of operations surveyed in 1986. The response rate was essentially unchanged. Production by nonresponding operations and by professional and amateur collectors was based on information from published data, gem and mineral dealers, gem and mineral shows, and collectors.

DOMESTIC PRODUCTION

Production of natural gem materials in all 50 states exceeded a value of $1,000. Ten States supplied 82% of the total value of natural gem material produced. The States, in order of declining value of production, were Tennessee, California, Arizona, Montana, Maine, North Carolina, Idaho, Oregon, and New Hampshire. Production of synthetic and simulant gem materials was valued at $15.3 million. Twelve firms, five in California, four in Arizona, and one each in Massachusetts, Michigan, and New Jersey, produced synthetic and simulant gem material. The States, in order of declining value of production, were Massachusetts, California, New Jersey, Michigan, and Arizona.

Dia Em Resources Ltd. and LKA Interna-

tional Inc. continued to evaluate the emerald occurrences on their Rist and Ellis Mines at Hiddenite, NC. LKA designed and built a beryllometer to assist in sorting emeralds from waste materials. The beryllometer contains a nuclear source material that allows the emerald to be located by induced radiation. The emerald is not permanently affected by the radiation.

The largest diamond ever reported from California was recovered in northern California during 1987. The 14.33 carat alluvial diamond was recovered while panning for gold in Trinity County. The diamond is a knotted grayish-green semitranslucent industrial-grade stone with adamantine luster.

The Dow Chemical Co.; Amselco Exploration Inc., a subsidiary of British Petroleum Co. of Canada; and Exmin Corp., a subsidiary of the Belgian company Sibeka (Société d'Entreprises et d'Investissements S.A.), continued exploration for diamonds on leased lands in Michigan and Wisconsin. Exmin continued diamond exploration efforts in Minnesota.

Ashton Mining Co., a subsidiary of the Australian company Ashton Mining Inc., conducted exploration for diamond in the Crooked Creek and Goodnews Bay areas of Alaska during 1987. The work in the Goodnews Bay area resulted in the recovery of some microindustrial diamonds.

Diamond Co. NL, a wholly owned subsidiary of the Australian company Carr Boyd Minerals Ltd., negotiated mining leases and commenced diamond exploration work in northern Colorado. The joint venture between Lac Minerals Ltd. and Mobil Oil Co. continued its diamond exploration project in the State Line District on the Colorado-Wyoming border.

The Diamond Mining Task Force, appointed in 1986 by the Arkansas Governor to assist the State Parks, Recreation, and Travel Commission in determining if commercial diamond mining would be allowed at the Crater of Diamonds State Park, continued to collect data and undertake studies. The engineering firm of Howard, Needless, Tammer, and Bergendorf was hired to prepare an engineering and economic fesibility study of the proposed diamond mining project. At yearend, studies were under way and no decisions had been made concerning the mining project.

A major discovery of some of the finest topaz crystals ever found in the United States was made at a small pegmatite situated in Coos County, NH. The crystals were sharp, lustrous, blue to blue-green or bicolored blue and golden brown; many were flawless. The same deposit also yielded 30 kilograms of high-quality gem smoky quartz rough.

American Pearl Farms of Tennessee completed its first significant harvest of cultured freshwater pearls. American currently has five pearl farms under operation and acquired additional water acreage for a sixth farm to be established during 1988. The new farm is planned to be nine times larger than the existing farms.

The Zales Diamond, a 535-carat nontraditional-shaped stone, cut in the United States in 1986, was recut into a traditional shape. The loss in carat weight resulted in the stone's no longer being the world's largest polished diamond. A 3,500-carat blue sapphire was found in North Carolina, and a 5,500-carat North Carolina star sapphire was cut into a 3,000-carat stone. No value was established for either of the sapphires. The world's largest gem topaz, a 22,892-carat light golden topaz, was cut from a 26-pound waterworn crystal. The cushion-cut stone was purchased by the rockhound hobbyists of America for $40,000 and will be donated to the Smithsonian Museum of Natural History.

CONSUMPTION

Domestic gem materials production was consumed in commercial and amateur manufacture of jewelry, in gem and mineral collections, and in the production of objects of art. The value of U.S. apparent consumption was estimated to be $3,459 million, an increase of about 4%.

U.S. imports for consumption of colored gem stones, led by emerald, ruby, and sapphire, decreased slightly. The value of annual imports of emerald continued as the largest of any colored gem stone. The combined value of imported ruby and sapphire in 1987 was exceeded by the value of emerald by 6%. In 1986, the combined values of ruby and sapphire exceeded emerald by 17%.

The value of imports of other colored stones increased 21% compared with those of 1986, and the value of imported synthetic and imitation gem materials increased 28%. The value of pearls imported into the United States continued to decline for the third consecutive year, decreasing approximately 20% compared with that of 1986. The fluctuation in the value of imports is a direct reflection of purchasing trends in the marketplace.

PRICES

The U.S. price of a 1-carat, D-colored, flawless diamond fluctuated between $14,000 and $16,000, and was $14,000 at yearend. However, only a few hundred of these high-quality, 1-carat stones have been available each year, and their value has accounted for an insignificant percentage of the total value in the U.S. market. Prices of ruby, blue sapphire, and emerald rose 39%, 35%, and 45%, respectively, when their June 1987 prices were compared with their June 1986 prices. The price increases appear to be the result of a combination of things: the lower American dollar, the increased demand in the United States for quality stones, and a decrease in the supply of stones from the traditional producing areas. The price of American freshwater pearls increased slightly over that of 1986, and the demand remained firm.

Table 1.—Prices of U.S. cut diamonds, by size and quality

Carat weight	Description, color[1]	Clarity[2] (GIA terms)	Price range per carat,[3] 1987	Average price per carat[4]	
				June 1986	June 1987
0.04-0.07	H-I	VS	$440- $440	$420	$400
.04- .07	H-I	SI_1	420- 420	380	420
.08- .14	H-I	VS	470- 470	460	470
.08- .14	H-I	SI_1	440- 440	420	440
.18- .22	H-I	VS	680- 680	750	680
.18- .22	H-I	SI_1	600- 600	700	600
.23- .29	H-I	VS	900- 900	11,750	900
.23- .29	H-I	SI_1	750- 750	900	750
.30- .37	H-I	VS	1,175- 1,225	1,475	1,175
.30- .37	H-I	SI_1	950- 950	1,250	950
.46- .49	H-I	VS	1,425- 1,525	--	1,475
.46- .49	H-I	SI_1	1,300- 1,300	--	1,300
.70- .89	H-I	VS	2,175- 2,175	2,175	2,175
.70- .89	H-I	SI_1	1,900- 1,900	1,800	1,900
1.00[5]	D	IF	14,750-14,000	[5]12,000	[6]14,500
1.00	E	VVS_1	6,200- 5,875	[6]5,000	[6]6,000
1.00	G	VS_1	3,350- 3,475	[6]3,150	[6]3,250
1.00	H	VS_2	2,650- 2,950	[6]2,525	[6]2,550

[1]Gemological Institute of America (GIA) color grades: D—colorless; E—rare white; and H-I—traces of color.
[2]Clarity: IF—no blemishes; VVS_1—very, very slightly included; VS—very slightly included; VS_2—very slightly included, but more visible; and SI_1—slightly included.
[3]Rapaport Diamond Report. V. 10, No. 1, Jan. 2, 1987; and v. 10, No. 45, Dec. 25, 1987. These figures represent Rapaport Diamond Report opinion of New York wholesale asking price.
[4]Rapaport Diamond Report. V. 9, No. 22, July 11, 1986; and v. 10, No. 23, June 26, 1987.
[5]The Diamond Registry Bulletin. V. 18, No. 1, Dec. 1986, p. 8; and v. 18, No. 1, Dec. 1987, p. 8.
[6]The Diamond Registry Bulletin. V. 17, No. 7, July 1986, p. 8; and v. 17, No. 6, July 1987, p. 8.

Table 2.—Prices of U.S. cut colored gem stones, by size[1]

Gem stone	Carat weight	Price range per carat, 1987[2]	Average price per carat[3]	
			June 1986	June 1987
Amethyst	1	$6- $10	$8	$8
Aquamarine	1	100- 250	175	175
Emerald	1	1,800-3,000	1,775	2,400
Garnet, tsavorite	1	500-1,200	950	950
Ruby	1	2,300-3,500	2,150	3,000
Sapphire	1	550-1,500	725	1,050
Tanzanite	1	275- 450	354	354
Topaz	1	6- 9	7.50	7.50
Tourmaline, red	1	60- 125	145	92.50

[1]Fine quality.
[2]Jewelers' Circular-Keystone. V. 159, No. 2, Feb. 1988, p. 400. These figures represent a sampling of net prices that wholesale colored stone dealers in various U.S. cities charged their cash customers during the month.
[3]Jewelers' Circular-Keystone. V. 159, No. 8, Aug. 1987, p. 442.

FOREIGN TRADE

Export value of all gem materials was $740.8 million. Export value of all gem materials other than diamond increased 36% to $80.4 million. Of this total, other precious and semiprecious stones, cut but unset, were valued at $45.4 million; other precious and semiprecious stones, not set or cut, $21.0 million; synthetic gem stones and materials for jewelry, cut, $5.8 million; pearls, natural, cultured, and imitation, not strung or set, $1.8 million; and other, $369.4 million. Reexports of all gem materials other than diamond increased 12% to $61.7 million. Reexport categories were synthetic gem stones and materials for jewelry, cut, $0.6 million; precious and semiprecious stones, cut but not set, $40.1 million; and other precious and semiprecious stones, natural not cut or set, $1.31 million.

The customs value of U.S. imports of rough and polished natural diamond, excluding industrial diamond, was down slightly to about $3.4 billion. Total imports of polished diamond came principally from Israel, 32%; Belgium, 28%; and India, 21%. They were valued at $3.0 billion, essentially unchanged from those of 1986. Imports of diamond greater than 0.5 carat came mostly from Israel, 38%; Belgium, 36%; and Switzerland, 8%. They decreased 15% in value to $1.1 billion. Imports in the less-than-0.5-carat category came mostly from India, 35%; Israel, 32%; and Belgium, 24%. The value increased 6% to $1.9 billion. The imports of rough diamonds increased 5% in caratage and decreased slightly in value. The Republic of South Africa accounted for only 7% of the value of the imports, down from 52% in 1986. However, the average carat value of imports from the Republic of South Africa increased from $499 to $758.

The total customs value of imported emerald decreased 8% to $141.6 million. The total value of ruby imports decreased 29% to $59.4 million, and sapphire imports decreased 22% to $74.0 million. Average carat values increased 24% for emerald to $68, 14% for ruby to $25, and 27% for sapphire to $28.

Table 3.—U.S. exports and reexports of diamond (exclusive of industrial diamond), by country

Country	1986		1987	
	Quantity (carat weight)	Value[1] (millions)	Quantity (carat weight)	Value[1] (millions)
Exports:				
Belgium-Luxembourg	205,565	$108.9	162,009	$122.9
Canada	19,176	13.7	24,943	17.8
France	3,148	6.9	1,943	4.3
Germany, Federal Republic of	2,286	3.1	3,842	4.0
Hong Kong	67,393	97.1	100,365	148.2
Israel	156,819	87.2	172,634	110.8
Japan	48,266	93.6	62,404	144.1
Singapore	5,810	7.5	5,686	7.0
Switzerland	19,318	85.4	30,161	76.3
Thailand	16,958	6.4	14,028	9.3
United Kingdom	6,405	7.8	4,151	8.2
Other	9,915	8.0	5,221	7.5
Total	561,059	525.6	587,387	660.4
Reexports:[2]				
Belgium-Luxembourg	806,945	89.5	1,184,952	101.1
Canada	6,516	.5	5,424	.8
China	10,392	.6	2,062	.1
Germany, Federal Republic of	39,479	2.7	24,840	2.6
Hong Kong	59,969	20.3	82,491	27.2
India	127,221	3.3	84,893	2.9
Israel	210,333	59.2	199,579	70.3
Japan	105,827	8.8	95,919	7.2
Netherlands	68,079	5.1	47,313	3.2
Switzerland	30,797	35.1	39,765	57.7
United Kingdom	398,044	27.6	101,300	18.4
Other	102,348	9.4	74,333	16.2
Total	1,965,950	262.1	1,942,871	307.7

[1]Customs value.
[2]Artificially inflated in 1986 by auction of approximately 1 million carats of U.S. Government stockpile industrial diamond stones with subsequent reexports as gem stones to Belgium-Luxembourg and India.

Source: Bureau of the Census.

Table 4.—U.S. imports for consumption of diamond, by kind, weight, and country

Kind, range, and country of origin	1986		1987	
	Quantity (carat weight)	Value[1] (millions)	Quantity (carat weight)	Value[1] (millions)
Rough or uncut, natural:[2]				
Belgium-Luxembourg	418,782	$73.8	323,742	$82.0
Brazil	29,444	3.4	44,287	5.4
Cape Verde	940	1.0	--	--
Guyana	2,122	.3	--	--
Israel	45,240	12.2	28,029	7.3
Netherlands	7,318	3.7	2,930	2.9
South Africa, Republic of	452,973	225.9	37,870	28.7
Switzerland	22,629	8.1	5,185	12.6
United Kingdom	135,099	66.0	797,759	208.3
Venezuela	37,096	1.0	7,901	.7
Other	155,618	39.7	121,657	72.1
Total	1,307,261	435.1	1,969,360	420.0
Cut but unset, not over 0.5 carat:				
Belgium-Luxembourg	1,540,601	471.9	1,307,990	468.2
Brazil	23,013	7.5	33,352	8.7
Canada	30,485	4.0	21,750	8.8
Hong Kong	131,717	25.0	241,251	41.8
India	2,886,722	629.0	3,198,504	670.8
Israel	1,555,742	542.7	1,511,724	629.8
Malaysia	2,151	.7	--	--
Netherlands	28,296	11.0	51,959	13.6
South Africa, Republic of	139,692	19.1	14,451	11.8
Switzerland	75,629	28.7	73,268	40.3
United Kingdom	36,714	17.9	18,321	15.8
Other	172,873	21.9	144,708	33.3
Total	6,623,635	1,779.4	6,617,288	1,942.9
Cut but unset, over 0.5 carat:				
Belgium-Luxembourg	412,645	371.1	334,789	380.1
Hong Kong	34,236	45.4	12,361	21.3
India	50,096	13.2	110,019	28.0
Israel	529,226	429.0	468,132	406.1
Netherlands	24,673	23.8	8,408	11.6
South Africa, Republic of	65,160	73.7	27,654	41.3
Switzerland	48,898	169.6	37,583	81.7
United Kingdom	35,303	63.8	29,155	42.6
Other	60,871	55.9	56,345	47.5
Total	1,261,130	1,245.5	1,134,441	1,060.2

[1]Customs value.
[2]Includes some natural advanced diamond.

Table 5.—U.S. imports for consumption of natural precious and semiprecious gem stones, other than diamond, by kind and country

Kind and country	1986		1987	
	Quantity (carats)	Value[1] (millions)	Quantity (carats)	Value[1] (millions)
Emerald:				
Argentina	437	(*)	--	--
Belgium-Luxembourg	16,262	$3.1	30,190	$3.9
Brazil	144,899	6.4	112,194	7.0
Colombia	199,935	52.3	195,403	44.6
France	10,674	3.0	8,401	1.9
Germany, Federal Republic of	60,471	3.2	38,034	3.9
Hong Kong	187,525	12.0	170,853	15.2
India	1,267,481	14.5	1,231,033	17.0
Israel	59,724	14.1	60,942	19.4
Japan	3,816	.8	5,637	.6
South Africa, Republic of	37,795	1.8	5	(*)
Switzerland	448,580	27.4	58,789	18.3
Taiwan	5,056	.3	3,697	(*)
Thailand	138,284	2.6	104,058	3.0
United Kingdom	20,461	6.1	7,652	2.2
Other	155,735	4.8	48,032	4.6
Total	2,757,135	152.4	2,074,920	141.6

See footnotes at end of table.

Table 5.—U.S. imports for consumption of natural, precious and semiprecious gem stones, other than diamond, by kind and country —Continued

Kind and country	1986		1987	
	Quantity (carats)	Value[1] (millions)	Quantity (carats)	Value[1] (millions)
Ruby:				
Belgium-Luxembourg	16,528	$4.8	12,078	$0.7
Brazil	579	(2)	3,102	(2)
Colombia	1,558	.1	3,198	(2)
France	4,563	1.9	6,219	1.6
Germany, Federal Republic of	14,412	.9	18,267	.8
Hong Kong	85,954	3.4	42,687	3.6
India	247,687	2.1	372,323	.9
Israel	35,488	1.3	7,043	.6
Japan	82,786	.4	335,381	.5
Switzerland	256,921	16.5	41,492	14.1
Thailand	3,020,440	44.4	1,536,723	31.4
United Kingdom	19,496	5.8	11,523	2.9
Other	82,677	2.4	37,781	2.3
Total	3,869,004	83.5	2,357,817	59.4
Sapphire:				
Australia	2,219	.2	--	--
Austria	--	--	1,000	(2)
Belgium-Luxembourg	19,152	3.0	21,356	1.2
Brazil	28,604	(2)	2,560	(2)
Canada	4,643	.7	6,905	.7
Colombia	1,769	(2)	2,234	(2)
France	26,764	1.9	7,048	1.1
Germany, Federal Republic of	20,699	1.2	12,067	1.6
Hong Kong	132,201	4.9	63,684	5.4
India	127,121	1.0	84,973	.5
Israel	40,322	1.2	14,254	1.1
Japan	29,157	.5	48,460	.4
Korea, Republic of	7,527	.1	9,793	(2)
Singapore	946	(2)	7	(2)
Sri Lanka	22,149	2.2	55,241	3.1
Switzerland	370,520	21.0	46,786	11.3
Thailand	3,394,602	50.3	2,121,376	42.7
United Kingdom	60,736	5.5	110,112	3.9
Other	71,587	1.4	37,847	1.0
Total	4,360,718	95.1	2,645,723	74.0
Other:				
Rough, uncut:				
Australia	NA	.6	NA	.8
Brazil		15.9		20.7
Colombia		7.5		5.5
Hong Kong		1.1		1.4
Nigeria		.3		.2
Pakistan		.6		1.2
South Africa, Republic of		.7		.3
Switzerland		.4		.1
United Kingdom		.4		(2)
Zambia		.7		.1
Other		3.0		3.8
Total	NA	31.2	NA	34.1
Cut, set and unset:				
Australia	NA	4.6	NA	6.1
Brazil		11.6		17.2
Canada		.8		.6
China		5.1		2.7
Germany, Federal Republic of		11.4		13.7
Hong Kong		29.3		28.7
India		4.8		5.7
Japan		161.9		128.8
Switzerland		2.9		3.0
Taiwan		12.1		11.1
Thailand		6.1		11.7
United Kingdom		2.5		1.0
Other		19.3		21.2
Total	NA	271.8	NA	251.5

NA Not available.
[1]Customs value.
[2]Less than 1/10 unit.

Source: Bureau of the Census.

Table 6.—Value of U.S. imports of synthetic and imitation gem stones, including pearls, by country

(Million dollars[1])

Country	1986	1987
Synthetic, cut but unset:		
Austria	0.5	1.3
France	.9	.8
Germany, Federal Republic of	6.4	9.2
Japan	9.0	1.8
Korea, Republic of	2.8	11.6
Switzerland	1.5	4.6
Other	1.0	5.0
Total	22.1	34.3
Imitation:		
Austria	34.4	50.7
Czechoslovakia	2.0	2.1
Germany, Federal Republic of	12.0	7.1
Japan	7.2	3.7
Other	7.0	8.0
Total	62.6	71.6

[1]Customs value.

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1986		1987	
	Quantity	Value[1]	Quantity	Value[1]
Diamonds:				
Rough or uncut[2]	1,307	$435,029	1,369	$420,604
Cut but unset	7,885	3,024,902	7,752	3,009,090
Emeralds: Cut but unset	2,757	152,396	2,075	141,575
Coral: Cut but unset, and cameos suitable for use in jewelry	NA	2,291	NA	3,060
Rubies and sapphires: Cut but unset	8,230	178,655	5,004	133,396
Marcasites	NA	139	NA	766
Pearls:				
Natural	NA	3,406	NA	3,879
Cultured	NA	190,497	NA	151,854
Imitation	NA	9,655	NA	6,259
Other precious and semiprecious stones:				
Rough, uncut	NA	30,589	NA	34,079
Cut, set and unset	NA	65,392	NA	78,215
Other	NA	8,102	NA	13,716
Synthetic:				
Cut but unset[3]	63,532	22,074	82,697	30,968
Other	NA	2,586	NA	3,358
Imitation gem stones	NA	52,989	NA	65,311
Total	XX	4,178,652	XX	4,089,520

NA Not available. XX Not applicable.
[1]Customs value.
[2]Includes 19,243 carats valued at $675,326 in 1986.
[3]Quantity in thousands of stones.

Source: Bureau of the Census.

WORLD REVIEW

De Beers Consolidated Mines Ltd.'s sales of uncut diamonds through the Central Selling Organization in 1987 were reported to be a record $3.07 billion compared with $2.56 billion in 1986, an increase of approximately 20%. Sales of colored gem stones also remained very strong.

Emerald was mined in Australia, Brazil, Colombia, Mozambique, Pakistan, the Republic of South Africa, the U.S.S.R., Zambia, and Zimbabwe. Sapphire was produced in Australia, Colombia, Kenya, Malawi, Nigeria, Sri Lanka, Tanzania, Thailand, and the United States. Aquamarine was

produced in Afghanistan, Brazil, China, India, Nigeria, Pakistan, the Republic of South Africa, Tanzania, the United States, and Zambia. Ruby was produced in Afghanistan, Burma, India, Kenya, Sri Lanka, Tanzania, Thailand, and the United States.

Angola.—Sociedade Portugesa de Empreendimentas and Endeama (SPE), a Portuguese company, signed a 2-year agreement with the Angolan state mining company to mine and appraise diamonds. SPE will also assist in diamond exploration and training Angolan personnel.[3] Visitors to Angola reported that Cuban soldiers stationed there were becoming good sources for Angolan rough diamonds. Angolan diamond production continued to suffer because of the civil war.

Australia.—Argyle Diamond Mines Joint Venture completed the second year of production from the AK-1 lamproite pipe. Production of 30.3 million carats exceeded the planned production of 25 million carats. Argyle Diamond Sales Ltd. launched a major sales campaign in October 1987 directed at significantly increasing the international market for "cognac" or "champagne" colored diamonds. The terms are used to help market the brown-colored gem diamonds Argyle produces each year.[3] Additionally, Argyle formed a direct relationship with the India diamond-cutting trade to upgrade its diamond cutting technology to reduce the amount of Argyle near-gem material that is reclassified as industrial because of cutting difficulties.[4]

Freeport Bow River Properties Inc., the operating company of the Freeport-McMoRan Australia Ltd. and Gem Exploration and Minerals Ltd. joint venture, started construction of the Bow River alluvial diamond project. The project will process 4,000 metric tons per day of gravel. Diamond output is expected to exceed 600,000 carats per year. The diamond production is forecast to be 18% to 25% gem quality, 65% to 72% near-gem quality, and 8% to 10% bort. Also, Freeport-McMoRan Australia made an encouraging diamond discovery while drilling its project at Orraroo in South Australia. Work continued on the joint venture diamond project between Freeport-McMoRan Australia and Swan Resources at Springfield Basin in New South Wales.

Carr Boyd Minerals Ltd., in partnership with the De Beers subsidiary Stockdale Prospecting Ltd., and Afro-West Mining and Gem Exploration and Minerals Ltd. are continuing separate diamond exploration projects in various Australian locations. Capricorn Resources Australian NL initiated offshore diamond prospecting 150 kilometers northwest of Wyndham on the northern coast of Western Australia. Ashton Mining Ltd. continued the management of two ongoing diamond exploration ventures. Gem Exploration completed a bulk-sampling program on a diamond prospect near the Kununurra District of East Kimberley and investigated magnetic anomalies in West Kimberley. The results were not announced. Auridian Consolidated NL continued its diamond exploration activities in North Shaw, Halls Creek, Pilbara, Mount Behn, Van Emmereck, Mount Barnett, and Pentagon areas.

Production of sapphire in 1987 was estimated to be $18 million and represented about 75% of the rough sapphire imported into Thailand, the world's leading sapphire processing and marketing country. The opal production in 1987 was estimated to be $58 million and represented about 85% of the world production of natural opal.[5] The South Sea cultured pearl production was estimated at $20 million. Australia produces about 25% of all South Sea pearls; however, the production represents approximately 80% of the high-quality goods.[6]

Botswana.—Debswana, the Botswana diamond mining company that is a 50-50 joint venture between De Beers and the Government of Botswana, sold its significant diamond stockpile to De Beers. The stockpile was estimated to contain a high proportion of large, high-quality gem material. The purchase was paid for with a combination of cash and newly issued De Beers company shares. The Government of Botswana now owns 2.6% of De Beers and the right to appoint two members to the Board of Directors of De Beers and De Beers' Diamond Trading Co.[7] Botswana produced a record high 13.2 million carats in 1987; approximately 71% were gem quality.

Brazil.—Mining and production started on a diamond-rich kimberlite pipe in the State of Mato Grosso, approximately 20 kilometers from Julina. This is the first production from a kimberlite pipe in Brazil. All production to date was from secondary alluvial sources.

The new alexandrite deposit mine discovered in early 1987 near Italira in Gerau Mines was temporarily closed late in the year by the Government. The location produced a large quantity of fine gem-quality alexandrite and promises to be prolific for the next several years.[8]

Table 8.—Diamond (natural): World production, by country[1]

(Thousand carats)

Country	1983			1984			1985			1986[p]			1987[e]		
	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total
Angola	775	259	1,034	652	250	902	464	250	714	240	10	e250	180	10	190
Australia	3,720	2,480	6,200	3,415	2,277	5,692	4,242	2,828	7,070	13,145	16,066	29,211	e13,650	e16,683	e30,333
Botswana	4,829	5,902	10,731	5,810	7,104	12,914	6,318	6,317	12,635	9,610	3,500	13,110	e9,367	e3,840	e13,207
Brazil	90	450	530	200	550	750	233	217	450	310	315	625	320	325	645
Central African Republic	230	65	295	236	101	337	190	87	277	259	99	358	245	105	350
China[e]	200	800	1,000	200	800	1,000	200	800	1,000	200	800	1,000	200	800	1,000
Ghana	34	306	340	35	311	346	60	572	632	50	510	560	60	540	600
Guinea	23	17	e40	44	3	47	123	9	132	190	14	204	e163	e12	e175
Guyana[e]	5	5	10	6	8	14	4	7	11	3	6	e9	4	7	11
India	12	2	14	13	2	15	14	2	16	13	2	15	13	2	15
Indonesia[e]	5	22	27	5	22	27	5	22	27	5	22	27	5	25	30
Ivory Coast[e 4]	NA	NA	NA	r20	r5	r25	r15	r5	r20	r10	r4	r14	15	5	20
Liberia	132	198	330	108	132	240	66	72	138	63	189	252	60	190	250
Namibia	915	48	963	884	46	930	865	45	910	r970	40	1,010	980	40	e1,020
Sierra Leone	242	103	345	240	105	345	243	106	349	215	100	315	200	100	300
South Africa, Republic of:															
Finsch Mine	1,765	3,278	5,043	1,714	3,184	4,898	1,770	3,184	4,954	1,821	3,208	5,029	1,455	2,701	e4,156
Premier Mine	800	1,844	2,644	765	1,785	2,550	820	1,864	2,684	882	1,977	2,859	772	1,713	e2,485
Other De Beers' properties[5]	1,400	569	1,969	1,452	593	2,045	1,500	569	2,069	1,428	529	1,957	1,427	546	e1,973
Other	589	66	655	585	65	650	460	35	495	342	41	383	409	30	439
Total	4,554	5,757	10,311	4,516	5,627	10,143	4,550	5,652	10,202	4,473	5,755	10,228	4,063	4,990	e9,053
Swaziland	—	—	—	7	10	17	9	12	21	17	23	e40	17	23	40
Tanzania	183	78	261	193	84	277	165	71	236	133	57	190	133	57	190
U.S.S.R.[e]	3,700	7,000	10,700	4,300	6,400	10,700	4,400	6,400	10,800	4,400	6,400	10,800	4,900	7,100	12,000
Venezuela	45	234	279	40	232	272	35	180	215	45	189	234	50	200	250
Zaire	3,355	8,627	11,982	5,169	13,290	18,459	4,032	16,127	20,159	4,661	18,643	23,304	4,670	18,680	23,350
Total	23,039	32,353	55,392	r26,093	r37,359	r63,452	26,233	39,781	66,014	39,012	52,744	91,756	39,295	53,734	93,029

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Table includes data available through June 3, 1988. Total diamond output (gem plus industrial) for each country is actually reported except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem and industrial diamond are Bureau of Mines estimates in the case of every country except Australia (1983-87), Botswana (1987), Central African Republic (1983-86), Guinea (1984-87), and Liberia (1984-86), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries, is based on the best available data at time of publication.

[2]Includes near-gem and cheap-gem qualities.

[3]Reported figure.

[4]Estimates based on reported exports; excludes smuggled diamonds.

[5]Other De Beers Group output from the Republic of South Africa includes Kimberley Pool, Koffiefontein Mine, and the Namaqualand Mines.

Canada.—Dia Met Minerals of Vancouver continued to negotiate the financing for drilling the Jack kimberlite pipe in British Columbia. The pipe, located 55 kilometers north of Golden, British Columbia, contains minute gem-quality diamonds. Additional pipes in the area were sampled during the summer months. Information from the summer program is not available at this time.

Central African Republic.—African Star Mining Co., a subsidiary of the U.S. firm O'Hair Mining and Drilling Co., established the first large-scale mechanized diamond mining operation in the Central African Republic. Two mines and associated washing plants with an initial production rate of 2,500 cubic meters per day were under construction with production scheduled to begin in early 1988. The firm planned to increase production to 5,000 cubic meters per day in 60 to 90 days after startup. The estimated average grade of the project reserves is 0.4 carat per cubic meter that grade 95% gem quality. Annual production is forecast to be approximately 670,000 carats per year. The planned production of the two operations is 200% of the current total production of the Central African Republic.

China.—Boarara Mining Ltd. of Australia entered into an agreement with Southolme Ltd. of Hong Kong to explore and develop diamond projects in Hunan Province in China. Diamonds are found along the 1,000-kilometer length of the Yuan Jiang River terraces and channels, which are often 20 to 30 meters deep and up to 300 to 400 meters wide. The terraces have been mined for years by local farmers. A source pipe for the diamonds has not been found.

The Yuan Jiang River Alluvial Project, a joint venture between City Resources (Asia) Ltd. (a subsidiary of the Australian company City Resource Ltd.), China Hunan International Development Corp., and China Geology Import and Export Group, was formed to explore for and produce diamonds and gold on the lower reaches of the Yuan Jiang River. City Resources will supervise and control the work and the Chinese partners will furnish the labor force. The project area is approximately 120 square kilometers.

China produced diamonds, aquamarine, quartz crystal, citrine, turquoise, peridot, sapphire, jet, pearls, and jade.

Guinea.—Diamond production at Badge Oil's Aredor project decreased. The diamonds from Aredor are noted for their size and quality with an average price of $284 per carat in 1987. The stones average 0.82 carat; however, an average of 55 gems over 10 carats and 10 stones over 15 carats was recovered each month. During 1987, a 100.2-carat stone was sold for $1.6 million, and a 143-carat stone was sold for $3.9 million. Production costs have been lowered from $260 per carat in 1984 to about $90 per carat in 1987.[9]

India.—Orissa Mining Corp. discovered a large deposit of high-quality ruby in Orissa State. The deposit in the Jilligdhar area of the Kalahandi District has made the company one of the largest producers of gem stones in the country. The smaller fine-quality stones sell wholesale at about $1,000 per carat. The lower quality stones suitable for cabochons sell for a few hundred dollars per carat once they are cut. The Government-owned Mineral Development Corp. announced the discovery of a major new diamond deposit in Chittaurgarh Province. Early reports indicate that the deposit may be more productive than any area currently being mined.

Indonesia.—Acorn Securities Ltd. continued negotiations with the Government of Indonesia for a long-term production agreement for the South East Kalimantan diamond project. The first parcel of diamonds from the project, 1,032 carats, was evaluated at an average value of $170 per carat. The parcel of 6,342 stones was 97% gem quality. Acorn has a reserve base of 16 million cubic meters with an average grade of 0.2 carat of diamond, 80 milligrams of gold, and 20 milligrams of platinum per cubic meter.

Pakistan.—Production from a new emerald deposit in Gujjar Kallay in the Swat District resulted in an increase in the average monthly production from 350 carats to 4,000 carats. The stones are of very good quality. Pakistan continued to produce high-quality pink topaz, other gem topaz, and tourmaline.

Sierra Leone.—Diamond Corp., a subsidiary of De Beers, negotiated with the Government of Sierra Leone regarding a $3 million loan to rehabilitate the mining equipment for the National Diamond Mining Co.'s operations at Yengema.[10] Oliver Resources PLC, through its Sierra Leone subsidiary, was granted exclusive gold and diamond licenses on about 78 square kilometers of alluvial deposits along tributaries of the Pampana River.

South Africa, Republic of.—Thirteen ad-

ditional marine diamond concessions were allocated off of the South African west coast. Fourteen companies or individuals are working the concessions that were issued in 1983 and 1984. The 1987 marine diamond production was estimated at 55,000 carats. De Beers began reactivation of the Koffiefontein Mine in the Orange Free State. The Mine, idle since 1982, is expected to be back in production in early 1988.

TECHNOLOGY

Shalev Computerized Systems Ltd. in Ramat Hasharon, Israel spent $2 million developing Robo Gem, a robot that automatically calculates the best possible shape and optimum yield of virtually all rough gems except diamond. The robot is more exact than human cutters, increases yields from rough stones an average of 10%, and reduces the cost of cutting by up to 70%.[11]

Zui Yehuda of Israel developed a method for treating diamonds that reportedly improves the clarity of fractured diamonds dramatically. In most diamonds the treatment can easily be identified with a 10X loupe. Many of the treated stones showed a yellow concentration of color along fractures. All of the treated stones displayed a distinct rainbow of color when viewed along the thin side of the fracture.[12]

Enhancement of all types of gem materials through chemical and physical means has become much more commonplace and has included a wider variety of gem materials in the past few years. Irradiation by the electromagnetic spectrum (X-rays, gamma rays, etc.) and by energetic particles (neutrons, electrons, alphas, etc.) is being used to enhance or change the color of diamonds, topaz, tourmaline, quartz, beryl, sapphire, zircon, scapolite, and pearls. Blue topaz is normally irradiated, but this does not imply that all of these gem materials are regularly irradiated.[13]

A number of gem materials can be enhanced by chemical treatment or impregnations. The treatment may alter the bulk of the gem material or only penetrate the surface. This includes bleaching, oiling, waxing, plastic impregnations, color impregnations, and dying. The treatments that alter only the surface of the gem material include surface coatings of various types, interference filters, foil backings, surface decoration, and inscribing. Chemical treatment is more widespread than the common dying of quartz, treatment of turquoise, and oiling of emeralds. Chemical treatment and impregnations have been used to enhance chalcedony, coral, ivory, pearl, tiger's eye, emerald, lapis lazuli, opal, ruby, sapphire, turquoise, beryl, quartz, jade, diamond, and amber.[14]

The oldest and most common method of gem material enhancement is heat treating. Heat treatment of gem materials was used in Greece and Rome well before the Christian Era. Heat treatment can cause color change, structural change, and improve clarity. In the past, heat treatment was common for quartz and gem corundum. Today, materials that are heat treated to enhance their appearance include sapphire, topaz, beryl, tourmaline, quartz, zircon, amber, diamond, and zoisite.[15]

Testing can determine if certain types of gem materials have been treated. However, not all types of treatments for all types of gem materials can be detected.

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